IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant: Takayuki Suzuki; Examiner. Jonathan C. Langman

Appln, No 10/821,957 Group Art Unit. 1794

Filed: April 12, 2004 Docket No . Q80989

For. SELF-SUPPORTED NITRIDE SEMICONDUCTOR SUBSTRATE AND ITS PRODUCTION METHOD, AND LIGHT-EMITTING NITRIDE SEMICONDUCTOR DEVICE USING IT

DECLARATION OF TAKAYUKI SUZUKI UNDER 37 CFR 1.132

Honorable Commissioner
For Patents and Trademarks
Washington, D.C. 20231

Honorable Commissioner.

I, Takayuki Suzuki, a citizen of Japan, declare and state that.

I am the inventor of the above-named application

I studied Materials Science in The Department of Engineering, Graduate School of Tohoku University and received my Master's degree in March, 2000.

I joined Hitachi Cable, Ltd, in 2000. I have been engaged in research and development relating to compound semiconductor materials, especially self-supported nitride semiconductor substrates, since the date I joined the Hitachi Cable, Ltd.

T. S.

I am currently an engineer on the Project Team for Developing GaN Substrates in the Compound Semiconductor Production Division of Hitachi Cable, Ltd.

I have reviewed the prosecution history of the present application and understand the prosecution history of the present application.

I have reviewed Final Office Action of June 9, 2009 and U.S. Patent 6,252,261 (to Usui et al, hereafter Usui) cited by the Examiner and relied upon by the Examiner to reject the claims of the above-named application.

In my opinion, Example 1 of Usui is representative of the teaching Usui, and serves as a basis to determine if Usui would, as the Examiner urges in the Action of June 9, 2009, form a nitride semiconductor film which would inherently possess the instantly claimed FWHM of less than 50 seconds in a {20-24} plane (Action, page 4, second full paragraph).

To confirm whether or not the Usui product posseses the characteristics of the claimed products, I conducted or had conducted under my direction and control the following experimentation.

Experimentation

According to the Example 1 disclosed in Usui, a self-supported thick GaN crystal film was formed on a sapphire substrate, followed by removing the sapphire substrate, etc.. Details on the procedures used by Usui are as set forth below.

A sapphire substrate [(0001) plane] with a diameter of 2 inches was prepared for growth of a GaN crystal film. A GaN film with a thickness of 1 μm (base crystal film) was formed on the sapphire substrate according to the following procedure.

First, the sapphire substrate was heated to 450°C in a MOCVD apparatus.

At this temperature, trimethylgallium (TMG: $(CH_3)_3Ga$) as a Ga source and ammonia (NH_3) were supplied to the MOCVD apparatus to grow GaN to a thickness of 400 Å. After the substrate temperature was increased to 1000°C, this GaN film (base crystal film) was further continuously grown to a thickness of 1 μm.

On the surface of this GaN film (base crystal film), an SiO_2 film of a thickness of 4 μm was deposited by a thermal CVD method using silane (SiH_4) and oxygen. A stripe shape patterning was then formed on the SiO_2 film by photolithography, i.e., coating a photoresist, UV exposure of the photoresist and developing of the photoresist. Using buffered hydrogen fluoride as an etchant, the SiO_2 film with stripe patterning was formed over the whole substrate surface. The growth area width for the thick GaN crystal film to be grown (i.e., the opening width of the mask) was 5 μm. The width of the mask was 2 μm. The direction of the stripe was arranged along the <11-20> direction. See FIG. 1A of Usui, attached hereto and incorporated herein by reference.

Next, the substrate with the mask as described above was placed in a hydride vapor phase epitaxy (HVPE) apparatus in which the thick GaN crystal film would be grown on the substrate. The GaCl gas supplied to the growth furnace of the HVPE apparatus was formed by reaction of Ga metal with HCl in the upper stream of a reaction tube at a temperature of around 800°C.

With the substrate in the HVPE apparatus, the substrate was heated to a growth temperature of 1000°C while in an atmosphere of hydrogen. After the growth temperature

became stable, HCl and NH_3 were supplied to the growth furnace for around 5 minutes at the flow rate of 20 cc/min and 1,000 cc/min, respectively, to grow GaN crystal facets of the {1-101} plane on the growth area (the opening of the mask). This epitaxial growth was further continued for around 20 minutes until the facets grown covered the mask. This is best illustrated in FIG. 1C of Usui attached hereto and incorporated by reference.

Further epitaxial growth embedded the facet structure in the grown film, and finally the GaN crystal film of a flat surface with a thickness of 200 μm was obtained after the growth for 5 hours. These steps are best if illustrated by FIG. 1D and FIG. 1E of Usui attached hereto and incorporated by reference. The thick GaN crystal film was cooled to room temperature in the NH_3 gas and was taken out of the HVPE apparatus.

A self-supported GaN substrate was produced by removing the sapphire substrate, the GaN film (base crystal film) and the mask from the back surface of the thick GaN crystal film discussed above. The removal was conducted by grinding.

With respect to the self-supported GaN substrate formed as described above, X-ray diffraction measurements were conducted for the (20-24) plane (reflection). An high resolution X-ray diffractometer (manufactured by PANalytical B. V.,) (Pert PRO MRD) equipped with a Ge (220) 4 crystals monochrometer was used for the measurement. Using an X-ray source of $CuK_{\alpha 1}$, X-ray beams generated under the condition of 40 kV and 45 mA were applied to the self-supported GaN substrate. The X-ray diffraction half width, i.e., FWHM (Full Width at Half Maximum), of the diffraction peaks was measured. The FWHM of the (20-24) plane (reflection) of the self-supported GaN substrate was 156 sec.

In my opinion, the above experimentation establishes that following the procedure of Usui, the X-ray diffraction half width of the claims of the present application, mainly an X-ray

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diffraction half width of 50 sec. or less in a {20-24} diffraction plane would not inherently be met by a self-supported nitride semiconductor substrate formed in accordance with Usui.

I declare further that all statements made herein on personal knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Date: August 10, 2009

Takayuki Suzuki

Takyuki Suzuki